ON THE

FRENCH METRIC SYSTEM

OF

WEIGHTS AND MEASURES,

WITH

OBJECTIONS TO ITS ADOPTION AMONG ENGLISH-SPEAKING NATIONS,

AND ON THE

DUODENAL ARITHMETICS AND METROLOGY.

BY

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ON

THE FRENCH METRIC SYSTEM

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OBJECTIONS TO ITS INTRODUCTION.

The proposition to introduce the French Metric System of Weights and Measures in this country, is a subject which requires to be well ventilated, so as to enable our legislative bodies and the public to form a correct idea of the expediency of its enforcement.

All the different, and even discordant, views which prevail in regard to changing our present conglomerate systems, and what would be the best to adopt in their stead, requires the greatest scrutiny, because such a change would not be a trifling affair, inasmuch as the difficulty is not only its very considerable expense, but the inconvenience accompanying it, entailed upon perhaps a whole generation.

Circumstances may be such, however, as to render it expedient to brave both the expense and the inconvenience, whatsoever they may be.

The conglomerate systems of weights and measures clung to by the English-speaking nations, are great inconveniences, not only to their own commerce, science and mechanic arts, but also to those of other nations who have advanced so far as to have established better systems—or rather, a common system.

The French Metric System is undoubtedly the best yet devised, and is therefore adopted by most of the continental nations of Europe, as also in South America, for which reason it already approaches closely to a universal system. Yet, the Metric System has some serious defects, namely, that it is not applicable to the division of the circle and of time, where binary and trinary divisions are required, and, therefore is inadmissible in Navigation, Astronomy, Geography and Chronology. These defects, however, are not limited to the metric system, but exist in all other systems of metrology, and are, therefore, not tenable objections to the introduction of this amongst the English-speaking nations.

The French, as is well known, divided the earth's quadrant from the equator to the pole, into ten million parts, with the intention of decimating the circle and time, in order to complete their metric system so as to make it applicable to chronology, navigation and geography, and, indeed, this was actually accomplished and enforced by law, October 5th, 1792, when the new decimal calendar was established in France. This decimal calendar was, however, found to be impracticable, and the people revolted against it, so that, after thirteen years' existence, the old calendar was restored September 9th, 1805.

Subsequent measurements of the size of our earth have proved that the adopted length of the French metre is not a correct ten-millionth part of the quadrant, and thus makes the metre as arbitrary a standard as any other unit of length, which fact, however, is not a tenable objection to the introduction of the metric system—because it has no connection with geography after the decimal division of the circle was abolished.

In altering the metrology of a country, the unit of length is the most difficult to change, and the English-speaking nations are so thoroughly imbued with the foot and the inch, that they consider it impossible not only to change that measure, but to properly conceive proportions and dimensions in other measures like the metre. Therefore, the unit of length requires pre-eminent discussion, and the remarks hereafter made on the metre, are also applicable to all other units in the metric system.

OBJECTIONS TO THE METRIC SYSTEM, AND TO ITS ADOPTION.

First Objection.

The Metre is too long. This objection is common among those who are not accustomed to its use. But on the other hand, many who have at first rebuffed it on that ground, and have afterwards been obliged to use it until well inured to its utility, say, " the two-foot rule is too short, and is mean-looking measure.

After becoming accustomed to the metre, it is really found to be a more suitable length than is the two-foot rule, which contains two units, and requires a special multiplication or doubling for a long measure.

Suppose a distance of 17 feet 9 inches is to be measured by a two-foot rule, which will go eight times and a piece of 21 inches over. Now multiply 8 by 2, which gives 16 feet; then subtract 12 from 21, which gives 9 inches; add 1 to 16, which gives 17 feet, and don't forget to add also 9 inches, and the distance is at last obtained to be 17 feet 9 inches, provided the multiplications, additions and subtractions were all made right.

The *Metre* will go five times in that distance, and the piece over will be 20 centimetres. The distance 5.20 metres is thus obtained directly from the counting and reading on the metre, without any extra arithmetic.

The foot is really too short a unit for ordinary measures, and therefore it has been found necessary to use two or three units in the foot-measure.

Besides, the complicated calculations necessary for the various English measures of length, surface and volume, are great inconveniences in practice, and often lead to errors, and even frauds.

Second Objection.

The Metre cannot be folded into four parts, without breaking the sub-units.

The metre is divided into 100 centimetres, of which there will be 25 units in each of the four parts, and these sub-units are therefore not broken. It is true, that the decimetres are broken, being 2½ in each of the four parts, but the expression "decimetre" is rarely or never used. The fractions of the metre are invariably expressed in centimetres and millimetres.

The divisions on the metre are numbered and read in centimetres; for instance, 3 or 4 decimetres are numbered 30 or 40 centimetres, as shown in Fig. 3.

The idea that the metre cannot be folded into four parts without breaking the sub-units, is, therefore, not a tenable objection to its adoption in our country.

Third Objection.

The Four-folded Metre is too long and inconvenient for the Pocket.

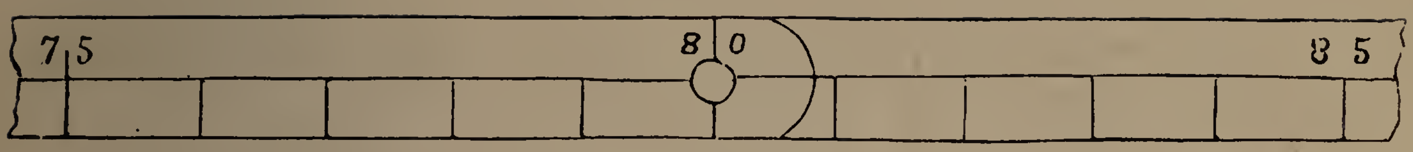
The four-folded metre is only 10 inches long, whilst the two-folded two-foot rule is 12 inches, or two inches longer.

The two-foot rule stretches a distance of only 24 inches, whilst the metre reaches nearly 40 inches. These facts are important items in favor of the metre.

The ten-folded metre is only four inches long, whilst the four-folded two-foot rule is 6 inches, or 2 inches longer; all in favor of the metre for the pocket.

The lap-jointed ten-folded metre, however, presents a broken line at the joints, (Fig. 1,) which is inconvenient for delicate measurements, but it is nevertheless generally used on the continent of Europe, and is, in fact, a convenient measure.

Fig. 1.



The best form of the French metre is that made with regular hinges, folding it into four parts, and the whole length divided into millimetres, such as manufactured by J. Tree, of London, being divided also into inches on the other side, so that either measure can at once be converted into the other without calculation.

There is no measure in any country, put together into such a variety of convenient forms as is the French metre.

A practical man does not consider the four-folded metre too long for the pocket, and the objection is therefore not tenable.

Fourth Objection.

One great objection to the introduction of the Metric System into other countries, has been that it is French; whereas, if the same had been devised and proposed by any other nation, the objection to it might possibly have been still greater.

Had the metric system been devised by a great many nations at the same time, it would no doubt have become a universal system long ago, and the prejudiced claimers could now be occupied in squabbling about who did it first, which they might dispute to a minute.

Fifth Objection.

The Metric System does not admit of binary division, as required in practice.

This objection is caused by the base 10 in our arithmetic not admitting binary divisions, and it is therefore impossible to combine decimals with binary fractions, without long rows of figures.

Binary fractions are, no doubt, very convenient in proportioning dimensions, and in the estimation of quantities, but when written in full on drawings, it is a clumsy notation, difficult to make distinct, and very often there is not room enough for the required vulgar fractions, whilst the metric notation is clear on the drawing. For example, $3\frac{13}{16}$ inches, containing five figures of different sizes in a heap, will, by the metric system, be expressed simply 97 m.m., meaning 97 millimetres, or 9 centimetres and 7 millimetres, which is a convenient notation.

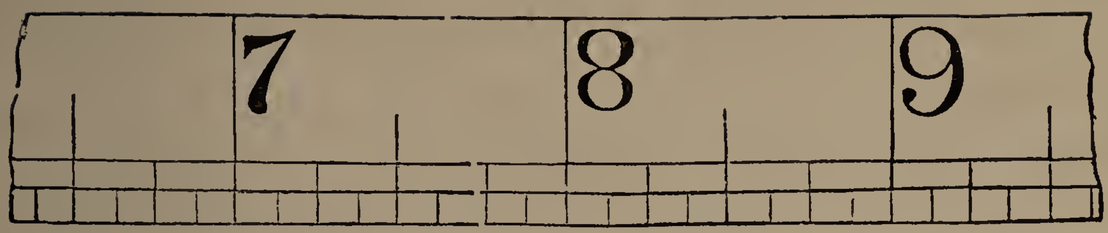
The arithmetical operation with vulgar fractions, is very difficult, and often leads to errors and confusion, and in fact, is a vulgar operation. For instance, $3\frac{21}{32}$ is to be added to $5\frac{13}{16}$: we have first $3 + 5 = 8$, and $\frac{21}{32} + \frac{13}{16} = \frac{21}{32} + \frac{26}{32} = \frac{47}{32}$, that is, $47 - 32 = 15$, or $1\frac{15}{32}$. Then add $8 + 1\frac{15}{32} = 9\frac{15}{32}$, provided the vulgar calculation was correctly made. There is no such vulgar operation in the metric system, and when we must multiply and divide with this kind of fractions, the operations become still more vulgar.

In designing work, it is often necessary to add a great many dimensions with different vulgar fractions, in order to get the aggregate distance, and the constructor very often repeats the addition a great many times, each giving different sums.

The same operation, with the metric system, works as easy as adding dollars and cents.

The foot-rule is generally divided into inches and eighths. (Fig. 2.)

Fig. 2.

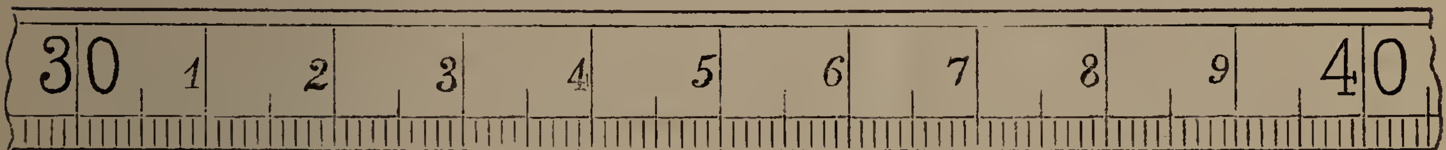


In measuring distances with this rule, the dimensions are generally expressed as follows: seven inches and one-eighth, full; eight inches and three-eighths, scant; nine inches and five-eighths and a sixteenth and a thirty-second, &c., &c.

There is no such vulgar language used with the metre.

Fig. 3 represents a full size decimetre, divided into millimetres, of which there are three per eighth of an inch, so that the inch expressions, "full" and "scant," or more vulgar, "and a sixteenth and a thirty-second," would no doubt fall in with a millimetre, and if not, the surplus is expressed by an additional decimal, without any vulgarity.

Fig. 3.



The measure is read directly from the metre, whilst the inch rule requires an additional calculation to get it right.

The four-folded metre is really the best measure for length yet in use, and the fact that it does not admit of binary and trinary divisions, is not the fault of the metre, but of the arithmetic base 10; and as long as that base is maintained, our metrology ought to be divided accordingly.

Those who advocate the use of binary fractions, ought also to advocate the introduction and adoption of binary arithmetic, and not to find fault with the decimal system without devising something better.

Sixth Objection.

The introduction of the Metric System would render it necessary to alter all drawings, patterns, taps, dies, reamers, mandrils, scale-beams, &c., &c., at enormous expense.

The change of the entire system of metrology of a country, must necessarily involve great inconveniences and expense, like the changing of a ferry for a bridge, or an up-and-down-hill crooked road, for a level and straight rail-road, but after the change is made, we roll over our difficulties with more ease, comfort and economy.

The English-speaking nations are far behind other countries in metrology, and the numerous inconveniences of our present cumbrous systems of weights and measures are severely felt, whilst the inconveniences of a change are not only of a mere temporary nature, but more apparent than real.

The only pre-eminence that can be justly claimed for our present metrology, is, that it is the same as was used by our great-grandfathers, which, however, is more than any other nation can boast of.

Seventh Objection.

The extensive English technical literature would become almost useless with the Metric System.

The metric system has been taught for many years in our principal institutions of learning, and most of the scientific and technical experiments are now made with it.

We have already some English books using the metric system exclusively, and the introduction of that system in this country, would enable us to utilize directly the French and German technical literatures, which are the richest in the world.

There will be no difficulty, however, in bringing out a new English technical literature, embodying the metric system, and accompanied with complete tables for converting either system into the other, whereby the old literature will not be lost.

Eighth Objection.

The French nomenclature of the Metric System would require a new language to be learned.

It is true that the metric nomenclature is unnecessarily complicated, but it is nevertheless already extensively used and embodied in the English language, (see Webster's Dictionary,) and if the metric system is adopted in America, its nomenclature could be considerably abbreviated.

The metric language is often used in our technical periodicals, even in daily papers, and is often cabled from Europe to America. The Sultan of Turkey committed suicide with a pair of scissors ten centimetres long.

If the dimensions had been cabled in archins or vershocks, the size of the scissors could have been correctly conceived only by Turks and Russians in this country, but the metric language we all understand.

The nomenclature in the English metrology is, however more complicated than that of the French. Questions are frequently asked of the true meaning of terms in our metrology.

The nations who have adopted the metric system, do not complain of its nomenclature.

Ninth Objection.

The Metric System is advantageous only to Teachers, Scientific Men and Calculators, but not to the Workers and Dealers in the market, who produce the wealth of the land.

It is the workers and dealers in the market, who would be the most benefited by the introduction of the metric system, and it is they who suffer most with the burden of our present cumbrous metrology, which few of them understand: and even the best scholar may find it to be more than he can keep clear in his cabéza.

The opposers to the introduction of the metric system, do not appear to comprehend their true interests, but when once introduced, the Americans will most likely take hold of it and appreciate it more quickly than any other nation, on account of their mixture of people descendants from all kinds of nationalities, which is the principal cause of our progress and prosperity.

Tenth Objection.

If a decimal system of weights and measures is required, it would be better to decimate our old units than to adopt the French Metric System.

The object of introducing the metric system, is not only to obtain a decimal system, but principally to follow up the progress of other nations in the use of a metrology which is approaching to become universal.

The decimation of our old units would be accompanied with nearly the same inconveniences and expense as if the metric system was adopted, and when finished, we would still have an odd metrology, different from that of other nations.

The foot divided into 100 parts, makes the divisions too coarse for delicate measurements, and if divided into 1000 parts, too fine for the naked eye, whilst the 1000th part of a metre makes a readable measure.

The Swedes acted upon the idea of decimating their old units of weights and measures, instead of adopting the metric system, and they have now a decimal system of metrology, which is as perfect as the French. Nevertheless, the Swedes are now advocating the adoption of the metric system, which will, no doubt, be soon accomplished, not with the idea that it is better than their own, but in order to follow up the progress of other nations in establishing a universal system of metrology.

We know the importance of having the digits or notation of numbers alike, or universal, as it nearly is.

Eleventh Objection.

The Metric System is not perfect, because it is not applicable in astronomy, geography, in the division of the circle and time.

True enough, but there is yet no other system of metrology which has not the same defects. With all the objections raised against the metric system, it is still the most complete in use.

The English-speaking nations have the worst system of metrology in existence, and they nevertheless find fault with the metric system, which is nearest to perfection.

The English are procrastinating with their cumbrous metrology, as they did with the Roman notation, and have always been behind other nations in advances of this kind.

A perfect system of metrology is universally desired, and the English-speaking nations ought either to adopt the French system as it is, or devise something better, and free from its defects—namely, a metrology which would be equally adapted to all kinds of measurements, including astronomy, geography, the circle and time, all admitting of binary and trinary divisions, as desired in the shop and the market.

The field is wide open for the English ingenuity to show that they can overcome the defects they complain of in the metric system.

If the English-speaking nations devise and adopt such a perfect system of metrology, other nations would, no doubt, rapidly follow their example.

Twelfth Objection.

Although the French metric system is the most complete of all in existence, we know that it has serious defects, as has been explained in the foregoing objections, and considering our fast progress in sciences and mechanic arts, it is reasonable to suppose that sooner or later a more perfect system of metrology will be devised and universally adopted, in which case the present French metric system would be abolished, and can therefore not be considered as a permanent system.

It is therefore advisable to give the subject a careful consideration before blindly adopting a system of metrology which we know has incurable defects.

In the ordinary course of business career among the English speaking nations, there appear to have been too few minds operating upon this highly important subject, which has therefore not received the circumspection it deserves, but has been limited to perceptions of mere temporary import.

Are we not yet sufficiently advanced to enable us to devise and adopt a perfect system of metrology, upon which we can depend to remain permanent in the future?

An example of a perfect system of metrology which is equally applicable to all kinds of measures, is given in the following appendix, which is taken bodily from the author's "Elements of Mechanics," without changing the folios.

This system involves the proposition of changing the base of arithmetic from 10 to 12, which requires two new digits to be added to the Arabic figures.

The two new figures will no doubt appear difficult and objectionable to hasty judges, whilst in reality, it is a difficulty of mere temporary import.

The English were obliged, when the Arabic digits supplanted the Roman notation, to learn nine new figures, whilst in the duodecimal arithmetic there are only two new figures to learn, and the Arabic figures retain their old value. If the duodecimal arithmetic and metrology was adopted, we could depend upon having a *permanent* and *perfect* system.

Some twenty years ago when the International Association for obtaining a uniform decimal system of weights, measures and coins, pressed the question upon the English Parliament of adopting the metric system, a committee was appointed to investigate the subject. The chairman of that committee, Lord Overstone, reported that the number 12 is a better base than 10, for the purpose of the shop and the market, and the adoption of the metric system was rejected on that ground.

No attempt was, however, made to re-organize the English metrology upon the base 12.

When the writer worked out the Senidenal system of arithmetic in London some sixteen years ago, he encountered a gentleman who was much interested in the subject, and well versed in the history and tradition of the difficulties in introducing the Arabic digits in England. He explained how the Houses of Parliament were casually burned by the papers of the Roman notation, and narrated the objections raised to the Arabic figures, in substance as follows:

"It would be ridiculous to introduce these curious-looking "Arabic characters into our beautiful language and letters, and our "people could never learn to understand or appreciate them.

"They have a character looking something like this, , which "is said to represent three. Look at our III. Any man without "learning can see that that means three. Another character like "this, , they say represents five. What is the use of adopting "such a sign for our beautiful V, which impresses the mind at once "that it means five. And then they put several of those signs "together like this,  , which, they say, means thirty-five. Who "can understand that? Our XXXV is clear, and can be understood "without any education, namely, that three tens and a five means "thirty-five. Such characters may answer very well for scientific "men who understand Arabic, but they are not practical for the "people."

Such a spirit of arguments will probably be brought to bear against the duodenal arithmetic and metrology.

The decimal arithmetic is the mean proportion between the Roman notation and the duodenal system: that is to say, the decimal arithmetic is so much superior to the Roman notation, as the duodenal is superior to the decimal.

The English conception of utility of the Arabic figures, (as appears in the quoted argument,) was limited to mere *notation*, without regard to arithmetic, which was then known only as far as could be used with Roman notation.

Such will no doubt be the case in judging of the utility of the duodenal system, namely, that the conception will be limited to what can be accomplished with decimal arithmetic, without regard to the power of the duodenal combination to impress the mind promptly with a clear perception of the most complicated problems.

THE FRENCH METRIC SYSTEM AT THE

Franklin Institute.

Discussion on the subject at the stated meeting May 17, 1876.

Vice-President Charles S. Close, in the chair.

Mr. President, and Members of the Institute:

I beg permission to make a few remarks upon the report of the Committee on Weights and Measures.

The circular of the Boston Society of Civil Engineers, asking the co-operation of the Franklin Institute in petitioning Congress to fix a date after which the metric weights and measures shall be the only legal standard in this country, was referred to a committee which has made one majority and one minority report.

The majority report has been printed and circulated in pamphlet form, as if approved by the Institute, and is opposed to recommending the adoption of the metric system in this country; to which opposition of the Committee, I have no objection: but before that report is adopted by the Franklin Institute, it is desirable that it should be based upon tenable ground, and not uttered in that spirit of depreciation of the metric system, and of the French nation which seems to have inspired the Committee.

That nation deserves great consideration for its struggle to introduce a universal system of metrology; an enterprise which, although universally desired, no other nation has ventured to undertake.

The majority report expatiates upon objections to the introduction of the metric system in this country, which are of mere temporary and insignificant import, very much like the English objections to the introduction of the Arabic figures for the Roman notation some 300 years ago.

The English were about 400 years behind the Continental nations in the introduction of our present Arabic digits.

The English thought that the introduction of the Arabic figures for the Roman notation, would obliterate all records and reckoning, and they expatiated upon the great difficulty and expense in making the alteration.

Now, the majority report on weights and measures to the Institute, is conceived in the same spirit, in regard to the introduction of the metric system.

What would our technical books, our arithmetic, reckoning and records be to-day with the Roman notation?

At the April meeting of the Institute, it was remarked that the majority report was *practical,* and the minority report *theoretical.*

In England, about 300 years ago, the Roman notation was considered *practical,* and the Arabic notation *theoretical,* and this identical distinction beween *practice* and *theory* appears to prevail at the Franklin Institute to-day.

The terms *practical* and *theoretical* are promiscuously used at the Institute, as a means of support to sciolism and perversion of the truth.

The difficulties which the French have experienced in establishing and introducing the metric system, are not tenable reasons for rejecting its adoption in this country.

The difficulties Fulton had in introducing steam navigation, are to-day no objections to its use.

The same can be said about Morse and the telegraph, and many other valuable advances upon which our progress and prosperity depend.

The Republic of Switzerland and other nations who from French example have adopted the metric system, did not experience the difficulty with their *reamers* and *mandrils* as intimated in the "practical" report.

The duty of technical and scientific men should be to consider, investigate and explain impartially, the comparative merit and demerit of the French and of our present system of metrology in all their bearings, and leave it for the law-makers to decide whether or not it would be expedient to introduce, or if necessary to enforce the metric system upon us. The majority of our committee, however, has taken it upon themselves to speak, not only for the Franklin Institute, but as though they represented the entire United States.

We have no substantial reasons for supposing that our lawmakers would enforce unjust laws, and the Americans are generally a law-abiding people upon whom various laws are enforced every day. It is not for the Franklin Institute to decide whether or not the introduction of the metric system in this country would be an unjust law.

We know from experience, history and tradition, that in all parts of the civilized world, communities do not always comprehend their true interests, and it has therefore been found necessary sometimes, to enforce laws by which to guide them into prosperity, as was the case in England, with the introduction, adoption and enforcement of the Arabic figures for the Roman notation before mentioned.

The enforcement of the Arabic figures in England, was made at the expense of burning the Houses of Parliament.

In case our law-makers should find it expedient to introduce or enforce the metric system upon us, they will no doubt give at least ten years' notice, in which time the present *reamers* and *mandrils* in a toolshop may be worn out, and if not, they will not be likely to conflict with any clause in the new law.

The "practical" Committee says, "the Franklin Institute "has never placed itself on record as opposing true progress." This statement conflicts with the tenor of their report, and moreover cannot be sustained in an impartial argument.

The Committee is "favorable to the introduction of a perfect "system of weights and measures," but they at the same time "hope "that no such opportunity may be presented in this country."

If this paradoxical language is approved by the Franklin Institute, it may be interpreted and understood that this Society favors progress, but will not give any opportunity for it. I admit that to be true, because I have experienced the fact, but fear that such acknowledgment on the part of the Committee would weaken the strength of their report.

The Committee refers to an article published in the Journal of the Franklin Institute, headed, "The Metric System in our Workshops," which article contains the same kind of feeble ideas on weights and measures, as those in the "practical" report.

The "practical" Committee says: "The universe under this "(metric) system, might be compared to a great French clock, having "the earth for its escape-wheel, whose equatorial motion would be "400 metres per second." They evidently expect that such a "practical" idea is good enough to be approved by the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts.

The "practical" report is intrinsically imprudent, and, moreover, is ungrateful to the French Government and people, and if adopted as it now reads, it will *stamp a mark of old-fogyism* upon the Franklin Institute, which can never be wiped out, and under no consideration can that report accomplish the effect intended by its authors.

I beg to be distinctly understood, that I do not advocate the introduction of the Metric System, nor am I against it or opposed to it; but only desire to see dispassionate justice done to it, and therefore feel it a duty to remonstrate against an unphilosophical and hasty disposition of so grave a subject, by a prejudiced Committee of our Society.

The tenor of the "practical" report, moreover, seems to border so closely upon arrogance and partiality, as to be scarcely admissible by any institution of learning.

A report of this kind ought to be devoted principally to substantial and essential facts bearing directly upon the expediency or inexpediency of introducing the metric system as the only legal standard of weights and measures in this country.

Under these impressions, Mr. President, I respectfully move that the majority report be returned to the Committee for reconsideration and revision.

The motion was seconded, but the President paid no attention to it. Strong efforts were made by the "practical" element to have the "practical" report adopted and published in the Journal.

A synopsis of the minority report was read, which protested against the majority report as a perversion of history, and the assumption that the present system is the best that can be devised; also the argument that the change will be attended with great cost. Mr. Washington Jones moved to adopt the majority report.

Mr. Orr moved as a substitute for Mr. Jones' motion, that both reports be accepted and printed in the Journal. Mr. Jones again moved the adoption of the majority report, and its transmission to the Boston Society of Civil Engineers.

On motion, the subject was postponed until next stated meeting.

The Committee on Weights and Measures, consisted of Wm. P. Tatham, *Chairman*, Coleman Sellers and Robert Briggs, of which the two former made the majority report, and the last-named the minority.

REVIEW OF THE MINORITY OR "THEORETICAL" REPORT.

The minority report is favorable to, and has a high opinion of the metric system, but thinks "that it is inexpedient to attempt at "present to anticipate, by enactment, the time when this great step in "the progress of human civilization and unity shall be taken by the "National Government of the United States; he does so solely upon "the grounds of the yet incomplete preparation and education of the "people, and their want of appreciation of the immense advantages in "the progress of the arts, and in the application of science which the "metric system presents."

"The universal introduction of the metric system is merely a "question of time. Within a century probably, it will be established "in our land. Possibly another century may pass before its complete "adoption is consummated."

This "theory" is evidently based upon the English procrastination for some 400 years with the Roman notation. It implies that the people of the United States are not sufficiently advanced in education and intelligence, as to be able to comprehend, appreciate and utilize the advantages of the metric system, within the next coming two centuries; that is to say we are two centuries behind the continental nations of Europe. This is sad news.

The majority and minority reports are published in the Journal of the Franklin Institute for June, 1876.

Philadelphia, June 14, 1876.

Whilst the foregoing pages were in press, information was received to the effect that the Swedish Parliament has passed a law to adopt the Metric System. About three years ago, the Motala Iron Works in Sweden, adopted the metric system exclusively for all locomotive work. The Medical Profession of Sweden has used the metric system for many years.

The United States Coast Survey has used the French metre exclusively in all triangulations, for the last 40 years.

There are two factories near Boston, Mass., and one in New Jersey, which use the metric system exclusively.

The only European nations which have not yet adopted the metric system, are England, Russia, Denmark and Greece. The Danes will soon follow the example of the Swedes.

The metric system is adopted all over South and Central America, and also in Mexico.

APPENDIX.

DUODENAL SYSTEM OF ARITHMETIC, MEASURES, WEIGHTS AND COINS.

The object of appending a treatise on a new system of arithmetic and metrology is to demonstrate what can be done with that subject, which demonstration might by that means be conveniently accessible to the student and to the public.

The problem of an international and complete system of metrology has at all times been esteemed an important desideratum, but no attempt has yet been made to remove the principal difficulty which is in the way, and we can expect no satisfactory metrology until its primary obstacle is removed.

The base **ten**, which is adopted in our present arithmetic, does not admit of binary and trinary divisions, as required in metrology. This is the principal difficulty in the way of establishing a satisfactory system of measures, weights and coins.

The number *10* is actually the worst even number that could have been selected as a base of numeration, for which either *8*, *12*, or *16* would have been better.

The inconveniences of the decimal base in metrology are well known, and have been explained at various times by various writers; but the present arithmetic is so thoroughly incorporated with civilization that it appears difficult to unlearn and get rid of the same for the substitution of something better.

The American Pharmaceutical Association appointed a committee, of which Alfred B. Taylor of Philadelphia was chairman, for the purpose of investigating the present condition of metrology with a view to its improvement, who gave the subject a very careful and deliberate consideration.

An elaborate report containing over *100* octavo pages of fine print was prepared and read before the annual session of the Association, held in Boston September *15*, *1859*. This report explains the inconveniences of the decimal arithmetic and of the French metrical system, illustrated by quotations from various authors of high authority.

In the course of this report Mr. Taylor proposed and elucidated an **Octonal System** of arithmetic and metrology.

Octonal System.

The octonal system has *8* to the base, which admits of binary division to unity without fractions. It would be an easy system to learn and manage in both arithmetical and mental calculations, but it requires a greater number of figures than the decimal system in expressing high numbers, and eight is too small as a base.

The octonal system, moreover, does not admit of trinary division, as is required in the circle and time.

Decimal System.

The decimal arithmetic is of Hindoo origin, and was imported into Arabia some one thousand years ago, from which it was spread throughout Europe and the entire civilized world.

The base **ten** originated from the *10* fingers, which were used for counting before characters were formed to denote numbers.

The base *10* admits of only one binary division, which gives the prime number *5* without fraction. The trinary divisions give an endless number of decimals. The decimal system is therefore not well suited for metrology, in which binary and trinary divisions are required.

It is this defect of the decimal system which has caused confusion in metrology and discordance among nations respecting the adoption of one common system of measures; which problem will never be satisfactorily solved as long as decimal arithmetic is maintained.

By examining the tables of measures and weights of different nations we find that binary and trinary divisions are invariably preferred, notwithstanding that decimal arithmetic must be used in their calculation.

The French decimal metrology is perhaps the best that can be devised in connection with decimal arithmetic; it looks very inviting and simple on paper, but what is gained by the metrical system in calculations is lost in the shop and market.

The defects of the metrical system are the defects of our arithmetic itself, and as long as decimal arithmetic is maintained the French system is the best of all that have yet been devised.

The slow adoption of the metrical system by other nations is sustained by good reasons—namely, that it does not constitute a complete, uniform and convenient system of metrology. The decimal system, as before stated, is not applicable to the admeasurement of the circle, of time and of the compass, where binary divisions are indispensable. The circle requires both binary and trinary divisions, neither of which can be accommodated by the decimal base.

When the metrical system was first established in France, it was intended to decimate also the circle and the time, which was soon found to be impractical and the idea abandoned.

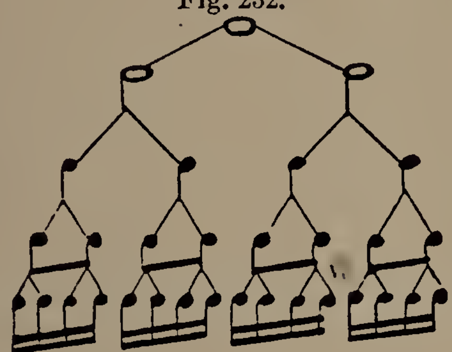
The French metrology is therefore not a complete system, and it has been renounced for all measures in astronomy, geography, navigation, time, the circle and the sphere, where it is inapplicable.

The decimal system is also inapplicable in music, where the binary and trinary divisions are invariably used.

Music represents the natural disposition of the mind to arrange or classify quantities. The musical bar is divided into *halves*, *quarters*, *eighths* and *sixteenths ;* and also into *thirds*, *sixths*, *ninths* and *twelfths ;* but we never find music divided into tenths.

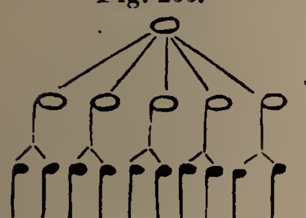
The most natural or binary division of music is represented thus:

Fig. 232.



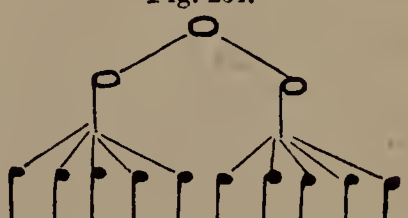
A bar of music divided by the decimal system would appear thus:

Fig. 233.



or if you please

Fig. 234.



No music could be produced by either of these last divisions, but a mechanical noise only could be made by it.

The lowest grade of man, and even animals, sing binary music. Even an Australian magpie can be taught to whistle any ordinary song as correctly as played on a musical instrument; whereas a decimal division of music could never be learned and appreciated even by the highest intelligence.

Such is also the comparison between binary and decimal arithmetic. Decimal arithmetic is a heavy burden upon the mind, and limits mental calculations within a very narrow compass; whilst binary or trinary arithmetic would become natural to the mind like music, and render mental calculations as easy as music played by the ear.

The Folded French Metre.

The French metre is difficult to fold into a convenient shape for the pocket. The ten-folded metre with lap-joints is a very convenient form for approximate measurements, but cannot be relied upon for correctness, because the numerous lap-joints cannot be made permanently accurate, and moreover the lap-joints do not form a straight but a broken line. The metre folded into five parts with lap-joints is an odd affair.

The two-folded metre of five decimetres in each part, of about *20* inches long, is too large for the pocket.

The four-folded metre makes two and a half decimetres in each part of about *10* inches long, which will answer for the pocket; and is perhaps the best form of the French metre when made with regular hinges like the English four-folded rule, but it is still a broken measure.

An international association for obtaining a uniform decimal system of weights, measures and coins has been in existence for over thirty years, and has yet accomplished very little. The object of this association is wholly for the introduction of the French metrical system, which has met with the most natural and reasonable objections—namely, that it is not a complete system, and that it is inconvenient in the shop and in the market; but the strong influence of this association has induced many governments to force that system upon their people.

In practice, we want our units divided into the simplest and most natural fractions—namely, *halves*, *thirds*, *quarters*, *sixths*, *eighths*, etc.—which cannot be done by the metrical system, or decimal arithmetic without long tails of figures commencing with 0.

For instance, the simple fraction $\frac{1}{3}$ expressed by decimals is 0.33333....... without end, and will never be correct, and requires a good education to understand the true meaning of it. The good scholar manages the decimal fractions as easily as a musician plays on his hand-organ, but the fraction 0.33333 is not so easily understood by the majority of the people, who will naturally ask what it means. In the answer it is necessary to explain that the unit is divided into 100000 parts, and 33333 of those parts is nearly $\frac{1}{3}$ of the whole. The people will then surely reply that they are not willing to cut their things up into 100000 parts and lose a portion by the division in order to get it into three.

Duodenal System.

Charles XII. of Sweden proposed to introduce a duodenal system of arithmetic and metrology. The king complained of ten as a base, and said, "It can be divided only once by 2, and then stops." The number *12* can be divided by 2, 3, 4 and 6 without leaving fractions; and divided by 8 gives $\frac{2}{3}$, by 9 gives $\frac{3}{4}$, and by 10 gives $\frac{5}{6}$, all convenient fractions for calculation.

The number *12* has always been a favorite base in metrology.

The old French foot was divided into *12* inches, the inch into *12* lines, and the line into *12* points. The *dozen* is a well-known base adopted all over the world; *12 dozens* is a *gross*, and *12 gross* is a *great-gross*. We have *12* months in a year, *12* hours in a day, *12* signs in the zodiac, *12* musical notes in an octave. The old Roman metrology was based on *12*, like the English foot and the Troy pound.

A writer in the Edinburgh Review (Jan., *1807*, vol. *9*, page *376*) regrets that the philosophers of France, when engaged in making so radical a change in the measures and standards of the nation, did not attempt a reform in the popular *arithmetic*. He, being in favor of a duodenal system, says, "The property of the number *12* which recommends it so strongly for the purpose we are now considering is its divisibility into so many more aliquot parts than ten, or any other number that is not much greater than itself. Twelve is divisible by *2*, *3*, *4* and *6*; and this circumstance fits it so well for the purpose of arithmetical computation that it has been resorted to in all times as the most convenient number into which any unit either of weight or measure could be divided. The divisions of the Roman *as*, the *libra*, the *jugerum*, and the modern foot, are all proofs of what is here asserted; and this advantage, which was perceived in rude and early times, would have been found of great value in the most improved eras of mathematical science. . . . We regret therefore that the experiment of this new arithmetic was not attempted. Another opportunity of trying it is not likely to occur soon.

"In the ordinary course of human affairs such improvements are not thought of, and the moment may never again present itself when the wisdom of a nation shall come up to the level of this species of reform."

If man had been created with six fingers on each hand, we would have had in arithmetic a duodenal instead of the present cumbrous decimal system.

A uniform duodenal system of metrology, even with decimal arithmetic, would be much better in the shop and market than the French metrical system.

A duodenal system would be equally applicable in all branches of metrology, and it would include those which are excluded by the metrical system—namely, astronomy, geography, navigation, time and the circle.

The duodenal system would require two new characters to represent *10* and *11*, so as to place *10* at *12*. This change in the figures would appear strange at the first glance, but a little reflection, with due consideration, would soon lead to the satisfaction that these two new figures simplify the arithmetic and render it much easier for mental calculation than decimal arithmetic.

Senidenal System.

The senidenal system has 16 to the base. A full elucidation of this system has been worked out by the author and was published in the year 1862 by J. B. Lippincott & Co., Philadelphia. It is called the tonal system.

The advantage of 16 as a base for arithmetic is that of its binary division to infinity. It is really the best system that could be devised for metrology and mental calculations.

The disadvantage of 16 as a base is that it requires six new figures to complete the base, which would be difficult to introduce, and also that it does not admit of trinary divisions, as is required in the circle and time, but it is under all circumstances far superior to the decimal system.

The difficulties with the decimal system are fully explained in the elucidation of the tonal system.

Scale of Four Arithmetical Systems.

Systems.	Base.	100	1000	10,000	100,000	1,000,000
Octonary.........	8	64	512	4,096	32,768	260,744
Denary...........	*10*	*100*	*1,000*	*10,000*	*100,000*	*1,000,000*
Duodenary......	12	144	1,728	20,736	238,832	2,865,984
Senidenary......	16	256	4,096	65,536	16,777,216	268,435,456

The names of the systems are Hindoo.

The octonary system requires the greatest number of places for expressing high numbers, for instance 1,000,000 octonal means only *260,744* of the decimal system.

The senidenary or tonal system uses less places; for instance, 1,000,000 senidenal means *268,435,456* of decimal numbers.

DUODENAL ARITHMETIC AND METROLOGY.

The base in the duodenal system is *12*, instead of *10* in the decimal system.

The Arabic system of notation is composed of ten simple digits, or characters—namely, *0*, *1*, *2*, *3*, *4*, *5*, *6*, *7*, *8*, *9*, and the base *10*.

These same characters can be used in the duodenal system by adding two numbers to complete the base—namely, *11* and *12*; then all the units of weights and measures should be divided and multiplied by *12*, but in order to render the system simple for calculation, it will be necessary to substitute new characters for the numbers *10*, *11* and *12*—namely,

Decimal system,	*1*, *2*, *3*, *4*, *5*, *6*, *7*, *8*, *9*, *10*, *11*, *12*;
Duodenary system,	1, 2, 3, 4, 5, 6, 7, 8, 9, ♈, ♉, 10,

in which 10 denotes the base *12*, ♈ stands for *10*, and ♉ stands for *11*.

The Italic figures mean decimal numbers, and the Roman figures mean duodenal numbers.

In order to distinguish the two systems from one another, it will be necessary to give new names to the duodenary figures.

A duodenary system of arithmetic cannot be adopted by only one nation, but the whole civilized world ought to agree upon such a scheme. Different nations have different languages and names for the decimal figures and numbers; but in the adoption of a duodenary system of arithmetic, one common nomenclature might be agreed upon.

The new figures and nomenclature appear to be the greatest objection to the introduction of the duodenal system of arithmetic and metrology.

There is no difficulty in convincing the public of the utility of the duodenal system, and with that impression, a pride will be taken in using the new nomenclature, which could be taught in every school; and each individual would attempt to follow up the time of education.

The following table contains the names of the figures and numbers up to twelve in different languages:

Nomenclature of Numbers in Different Languages.

No.	English.	French.	German.	Swedish.	Spanish.	Latin.	Greek.
0	Naught.	Zéro.	Null.	Noll.	Cero.	Nihil.	Zero.
1	One.	Un.	Eins.	En.	Uno.	Unus.	Eis, En.
2	Two.	Deux.	Zwei	Två.	Dos.	Duo.	Duo.
3	Three.	Trois.	Drei	Tre.	Tres.	Tres.	Treis.
4	Four.	Quatre.	Vier.	Fyra.	Cuatro.	Quatuor.	Tessares.
5	Five.	Cinq.	Funf.	Fem.	Cinco.	Quinque.	Pente.
6	Six.	Six.	Sechs.	Sex.	Seis.	Sex.	Hex.
7	Seven.	Sept.	Siben.	Sju.	Siete.	Septem.	Hepta.
8	Eight.	Huit	Acht.	Åtta.	Ocho.	Octo.	Okto.
9	Nine.	Neuf.	Neun.	Nio.	Nueve.	Novem.	Ennea.
10	Ten.	Dix.	Zehn.	Tio.	Diez.	Decem.	Deka.
11	Eleven.	Onze.	Elf.	Elva.	Once.	Undecem.	Endeka.
12	Twelve.	Douze.	Zwölf.	Tolf.	Doce.	Duodecem.	Dodeka.

No.	Russian.	Finnish.	Welsh.	Gaelic.	Gothic.	Turkish.	Hebrew.
0	Nill.	Nolli.				Zuffer.	Ayin.
1	Odna.	Yksi.	Una.	Unah.	Ains.	Bier.	Aleph.
2	Dva.	Kaksi.	Dou.	Gha.	Tvai.	Icki.	Beth.
3	Tri.	Koleme.	Tri.	Trec.	Threis.	Utch.	Gimel.
4	Tcheteri.	Nelja.	Pedvar.	Cheir.	Fidvor.	Duert.	Daleth.
5	Piat.	Viisi.	Pump.	Coag.	Finf.	Bach.	He.
6	Shest.	Kunsi.	Chewech.	Seach.	Saihs.	Altoe.	Vau.
7	Sem.	Seitsemän.	Saith.	Sheach.	Sibum.	Yedi.	Zain.
8	Vosem.	Kahdeksän.	Wyth.	Oacht.	Ahtan.	Seckiz.	Bheth.
9	Deviat.	Yhdeksän.	Nan.	Nuegh.	Niun.	Dokus.	Teth.
10	Desiat.	Kymmenän.	Deg.	Doach.	Taihun.	On.	Yod.
11	Odenatset.	Yksitoista.	Undeg.	Undech.	Ainstaihun.	Onbier.	Yodaleph.
12	Dvenatset.	Kaksitoista.	Doudeg.	Ghadech.	Tvaitaihun.	Onicki.	Yodbeth.

No.	Arabian.	Persian.	Hindoo.	Chinese.	Japanese.	Sanscrit.	Duodenal
0	Siforon.			Bow.	Ley.		Zero, 0
1	Ahed.	Yika.	Ek Ache.	Yat.	Itchi.	Aika.	An, 1
2	Ishnan.	Du.	Do.	Ge.	Ni.	Dwan.	Do, 2
3	Saylaset.	Seh.	Ien.	Sam.	San.	Tri.	Tre, 3
4	Erbayet.	Chehaur.	Chār.	Tze.	Tchi.	Chatur.	For, 4
5	Jemset.	Pendj.	Pánoh.	Ngnu.	Go.	Pancha.	Pat, 5
6	Sittet.	Shesh.	Chha.	Luck.	Lock.	Shash.	Sex, 6
7	Saybet.	Helft.	Sáth.	Tchut.	Sytchi.	Saptan.	Ben, 7
8	Saymaniet.	Hesht.	Ath.	Pbat.	Hatchi.	Ashta.	Ott, 8
9	Tiset.	Nuh.	Nau.	Geo.	Ku.	Navan.	Nev, 9
10	Eshret.	Deh.	Das.	Shop.	Dgiu.	Dashan.	Dis, ♈
11	Ahedeshere.	Yikadeh.	Gyárah.	Shopyat.	Dgiuitchi.	Aikadashan.	Elv, ♉
12	Ishnaneshere.	Dudeh.	Bárah.	Shopgaa.	Dgiuni.	Dwandashan.	Ton,10

COMMENTS ON NOMENCLATURE.

On account of the different pronunciations of letters and words in different languages, the true sound of a name cannot be conceived without a knowledge of the language in which it is written.

The Japanese sound for 9 is written *ku* in the table, but for the English pronunciation it should be written *koo*.

There are some letters of the alphabet which have nearly the same sound in all languages, and only such letters should be used in the coining of names for the figures and numbers in the duodenary system.

The letters *th*, *w*, *o*, *ur*, *ght* in the English language, and also the letter *C*, which has two sounds in almost all languages, should not be used for the new names.

The names given to the duodenary figures in the last column are clear and distinct sounds, which would be well understood and pronounced alike in all languages.

It would be useless to attempt to introduce the names of the figures and numbers in either of the languages above given as a universal nomenclature, for not only that they are not suited for more than the language in which they are written, but prejudices would be against them. The introduction of the French metrical system has been greatly retarded by reason merely of its cumbersome nomenclature.

The best work on the etymology of numbers known to the author is that of Professor S. Zehetmayr, published in Leipsic, 1854. In the establishment of a new and universal nomenclature of numbers we ought to select clear and distinct sounds, which can be understood and pronounced alike in all languages, without regard to the etymology of numbers.

The Arabic notation of numbers is yet used only by about one-third of the population of the earth, and the other two-thirds use different kinds of irregular characters or hieroglyphics, which combinations are unfit for arithmetical calculations.

The Roman notation was used in England up to the beginning of the seventeenth century, when the Arabic notation was gradually gaining ground against very strong opposition; and at last caused the burning of the houses of Parliament. The Arabic notation was introduced into Germany in the twelfth century, and into Italy in the eleventh century.

Comparison of Numbers in the Duodenary and Decimal Systems, with the Corresponding New Names.

New.	Names.	Old.	New.	Names.	Old.
0	Zero	*0*	37	Tretoben	*43*
1	An	*1*	38	Tretonott	*44*
2	Do	*2*	39	Tretonev	*45*
3	Tre	*3*	3♀	Tretondis	*46*
4	For	*4*	3♉	Tretonelv	*47*
5	Pat	*5*	40	Forton	*48*
6	Sex	*6*	41	Fortonan	*49*
7	Ben	*7*	42	Fortondo	*50*
8	Ott	*8*	43	Fortontre	*51*
9	Nev	*9*	44	Fortonfor	*52*
♀	Dis	*10*	45	Fortonpat	*53*
♉	Elv	*11*	46	Fortonsex	*54*
10	Ton	*12*	47	Fortoben	*55*
11	Tonan	*13*	48	Fortonott	*56*
12	Tondo	*14*	49	Fortonev	*57*
13	Tontre	*15*	4♀	Fortondis	*58*
14	Tonfor	*16*	4♉	Fortonelv	*59*
15	Tonpat	*17*	50	Paton	*60*
16	Tonsex	*18*	51	Patonan	*61*
17	Toben	*19*	52	Patondo	*62*
18	Tonott	*20*	53	Patontre	*63*
19	Tonev	*21*	54	Patonfor	*64*
1♀	Tondis	*22*	55	Patonpat	*65*
1♉	Tonelv	*23*	56	Patonsex	*66*
20	Doton	*24*	57	Patoben	*67*
21	Dotonan	*25*	58	Patonott	*68*
22	Dotondo	*26*	59	Patonev	*69*
23	Dotontre	*27*	5♀	Patondis	*70*
24	Dotonfor	*28*	5♉	Patonelv	*71*
25	Dotonpat	*29*	60	Sexton	*72*
26	Dotonsex	*30*	61	Sextonan	*73*
27	Dotoben	*31*	62	Sextondo	*74*
28	Detonott	*32*	63	Sextontre	*75*
29	Detonev	*33*	64	Sextonfor	*76*
2♀	Dotondis	*34*	65	Sextonpat	*77*
2♉	Dotonelv	*35*	66	Sextonsex	*78*
30	Treton	*36*	67	Sextoben	*79*
31	Tretonan	*37*	68	Sextonott	*80*
32	Tretondo	*38*	69	Sextonev	*81*
33	Tretontre	*39*	6♀	Sextondis	*82*
34	Tretonfor	*40*	6♉	Sextonelv	*83*
35	Tretonpat	*41*	70	Benton	*84*
36	Tretonsex	*42*	71	Bentonan	*85*

New.	Names.	Old.	New.	Names.	Old.
72	Bentondo..........	*86*	↋1	Elvtonan..........	*133*
73	Bentontre	*87*	↋2	Elvtondo..........	*134*
74	Bentonfor..........	*88*	↋3	Elvtontre	*135*
75	Bentonpat	*89*	↋4	Elvtonfor.........	*136*
76	Bentonsex..........	*90*	↋5	Elvtonpat.........	*137*
77	Bentoben...........	*91*	↋6	Elvtonsex.........	*138*
78	Bentonott..........	*92*	↋7	Elvtoben	*139*
79	Bentonev...........	*93*	↋8	Elvtonott..........	*140*
7↊	Bentondis..........	*94*	↋9	Elvtonev	*141*
7↋	Bentonelv	*95*	↋↊	Elvtondis.........	*142*
80	Otton	*96*	↋↋	Elvtonelv.........	*143*
81	Ottonan	*97*	100	San.................	*144*
82	Ottondo	*98*	148	San-fortonott	*200*
83	Ottontre............	*99*	200	Dosan.....	*288*
84	Ottonfor............	*100*	210	Dosan-ton	*300*
85	Ottonpat............	*101*	300	Tresan.............	*432*
86	Ottonsex............	*102*	358	Tresan-patonott..	*500*
87	Ottoben.......... .	*103*	400	Forsan.............	*576*
88	Ottonott	*104*	420	Forsan-doton	*600*
89	Ottonev	*105*	500	Patsan	*720*
8↊	Ottondis............	*106*	568	Patsan-sextonott.	*800*
8↋	Ottonelv...	*107*	600	Sexan	*864*
90	Nevton.............	*108*	630	Sexan-treton	*900*
91	Nevtonan	*109*	700	Bensan.............	*1008*
92	Nevtondo	*110*	800	Ottsan	*1152*
93	Nevtontre..........	*111*	900	Nevsan............	*1296*
94	Nevtonfor..........	*112*	↊00	Dissan	*1440*
95	Nevtonpat..........	*113*	↋00	Elvsan.............	*1584*
96	Nevtonsex..........	*114*	1000	Tos	*1728*
97	Nevtoben..........	*115*	1100	Tossan	*1872*
98	Nevtonott..........	*116*	1200	Tosdosan..........	*2016*
99	Nevtonev...........	*117*	1300	Tostresan	*2160*
9↊	Nevtondis..........	*118*	1400	Tosforsan..........	*2304*
9↋	Nevtonelv..........	*119*	1500	Tospatsan.........	*2448*
↊0	Diston..............	*120*	1600	Tossexan	*2592*
↊1	Distonan...........	*121*	1700	Tosbensan	*2736*
↊2	Distondo...........	*122*	1800	Tosottsan..........	*2880*
↊3	Distontre...........	*123*	1900	Tosnevsan	*3024*
↊4	Distonfor	*124*	1↊00	Tosdissan	*3168*
↊5	Distonpat	*125*	1↋00	Toselvsan.........	*3312*
↊6	Distonsex	*126*	2000	Dotos..	*3456*
↊7	Distoben...........	*127*	4000	Fortos..............	*6912*
↊8	Distonott	*128*	6000	Sextos..............	*10368*
↊9	Distonev...........	*129*	8000	Ottos...............	*13724*
↊↊	Distondis..........	*130*	↊000	Distos..............	*17180*
↊↋	Distonelv	*131*	10000	Dill	*20736*
↋0	Elvton.............	*132*			

FRACTIONS.

Duodenary System.	Decimal System.
$\frac{1}{2}$ = 0.6	$\frac{1}{2}$ = *0.5*
$\frac{1}{4}$ = 0.3	$\frac{1}{4}$ = *0.25*
$\frac{3}{4}$ = 0.9	$\frac{3}{4}$ = *0.75*
$\frac{1}{8}$ = 0.16	$\frac{1}{8}$ = *0.125*
$\frac{3}{8}$ = 0.46	$\frac{3}{8}$ = *0.375*
$\frac{5}{8}$ = 0.76	$\frac{5}{8}$ = *0.625*
$\frac{7}{8}$ = 0.Ϙ6	$\frac{7}{8}$ = *0.875*
$\frac{1}{3}$ = 0.4	$\frac{1}{3}$ = *0.3333.* . . . . . .
$\frac{2}{3}$ = 0.8	$\frac{2}{3}$ = *0.6666.* . . . . . .
$\frac{1}{6}$ = 0.2	$\frac{1}{6}$ = *0.16666* . . . . . .
$\frac{5}{6}$ = 0.Ϙ	$\frac{5}{6}$ = *0.83333* . . . . . .
$\frac{1}{14}$ = 0.09	$\frac{1}{16}$ = *0.0625*
$\frac{3}{14}$ = 0.23	$\frac{3}{5}$ = *0.1875*
$\frac{7}{14}$ = 0.53	$\frac{7}{16}$ = *0.4375*
♉/14 = 0.83	$\frac{11}{16}$ = *0.6875*
$\frac{1}{20}$ = 0.06	$\frac{1}{24}$ = *0.041666.* . . . . .
$\frac{7}{20}$ = 0.36	$\frac{7}{24}$ = *0.2916666.* . . . .
♉/20 = 0.56	$\frac{11}{24}$ = *0.458333.* . . . . .
$\frac{1}{28}$ = 0.046	$\frac{1}{32}$ = *0.03125*
$\frac{7}{28}$ = 0.976	$\frac{7}{32}$ = *0.21875*
$\frac{1}{9}$ = 0.14	$\frac{1}{9}$ = *0.11111111* . . . .
$\frac{2}{9}$ = 0.24	$\frac{2}{9}$ = *0.22222* . . . . . .
$\frac{4}{9}$ = 0.54	$\frac{4}{9}$ = *0.44444* . . . . . .
$\frac{5}{9}$ = 0.68	$\frac{5}{9}$ = *0.55555* . . . . . .
$\frac{8}{9}$ = 0.Ϙ8	$\frac{8}{9}$ = *0.88888* . . . . . .
♉/28 = 0.416	$\frac{11}{32}$ = *0.34375*
$\frac{17}{28}$ = 0.646	$\frac{17}{32}$ = *0.53125*
$\frac{1}{54}$ = 0.023	$\frac{1}{64}$ = *0.015625*
♉/54 = 0.209	$\frac{11}{64}$ = *0.171875*
$\frac{33}{54}$ = 0.739	$\frac{39}{64}$ = *0.609375*

The above table of fractions shows the simplicity of the duodenary system, which requires few figures where the old system requires a great number of decimals. For 3ds, 6ths, 9ths, 12ths and 24ths the duodenary system finishes the fraction with one or two places where the number of decimals is endless.

Addition Table.

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Ꝑ**	**℧**	**10**
2	4	5	6	7	8	9	Ꝑ	℧	10	11	12
3	5	6	7	8	9	Ꝑ	℧	10	11	12	13
4	6	7	8	9	Ꝑ	℧	10	11	12	13	14
5	7	8	9	Ꝑ	℧	10	11	12	13	14	15
6	8	9	Ꝑ	℧	10	11	12	13	14	15	16
7	9	Ꝑ	℧	10	11	12	13	14	15	16	17
8	Ꝑ	℧	10	11	12	13	14	15	16	17	18
9	℧	10	11	12	13	14	15	16	17	18	19
Ꝑ	10	11	12	13	14	15	16	17	18	19	1Ꝑ
℧	11	12	13	14	15	16	17	18	19	1Ꝑ	1℧
10	12	13	14	15	16	17	18	19	1Ꝑ	1℧	20

Multiplication Table.

	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Ꝑ**	**℧**	**10**
2	4	[illegible]	8	Ꝑ	10	12	14	16	18	1Ꝑ	20
3	6	9	10	13	16	19	20	23	26	29	30
4	8	10	14	18	20	24	28	30	34	38	40
5	Ꝑ	13	18	21	26	2℧	34	39	42	47	50
6	10	16	20	26	30	36	40	46	50	56	60
7	12	19	24	2℧	36	41	48	53	5Ꝑ	65	70
8	14	20	28	34	40	48	54	60	68	74	80
9	16	23	30	39	46	53	60	69	76	83	90
Ꝑ	18	26	34	42	50	5Ꝑ	68	76	84	92	Ꝑ0
℧	1Ꝑ	29	38	47	56	65	74	83	92	Ꝑ1	℧0
10	20	30	40	50	60	70	80	90	Ꝑ0	℧0	100

The duodenal multiplication table of the single figures is 44 per cent. more extensive than that of the decimal, but the binary and trinary properties makes it much easier to learn and to remember.

Examples in Addition.

```
38♀45♉3        8♀093        0.03
6108♉♀5         9♉6♀       ♉3.06
-------                    4♀9.♀1
99♉1598          ♀3♉      674♉.60
                  3♀     39♀06.00
                -----    --------
                98♀♉♀    44♉36.4♀
```

Examples in Subtraction.

```
74♉8♀6       3♀43.♉1       0.♉48♀6
314364       1♉9♀.0♀       0.003♉♀
------       -------       -------
437542       1♀65.♀3       0.♉44♀8
```

Examples in Multiplication.

```
  8694        ♀4♉63        36♉.3♀45
    24          63♉          0.0♉6
------      -------      ----------
 2♀314       956689       1957♉226
 5168       272♀69       32442507
------      -------      ----------
 7♉994     525916        34.19♀4296
           --------
           55♀36759
```

Examples in Division.

```
42)136♉0♀(38♀4          4♀.♉)3♀057.63♀(946.38
   106                       3823
   ---                       ----
    30♉                       1♀27
    294                       1778
    ---                       ----
     370                        26♉6
     358                        2556
     ---                        ----
      14♀                        1603
      148                        1289
      ---                        ----
      002                         3364
                                  333♀
                                  ----
                                    36
```

On account of the binary and trinary properties of the duodenary system, these arithmetical operations are much easier to the mind than those with decimal arithmetic. The only difficulty about it is to unlearn the decimal system.

The duodenary system has all the advantages and none of the disadvantages of the decimal system; it is also better adapted to mental calculations, which are very difficult with our present arithmetic.

METROLOGY.

The utility of a duodenary system of arithmetic consists in its combination with a similar system of metrology—namely, that all units of measure should be divided and multiplied by the same base, twelve.

Units of measure are required for the following fifteen quantities.

Length.	Weight.	Heat.	Force.	Power.
Surface.	Mass.	Light.	Velocity.	Space.
Volume.	Money.	Electricity.	Time.	Work.

Measurement of Length.

Assume the mean circumference of the earth to be the primary unit of length, and divide it by *twelve* repeatedly until the divisions are reduced to a length which would be a convenient unit to handle in the shop and in the market.

The mean circumference of the earth is about *24851.64* miles, which, multiplied by *5280*, will be

		Duodenal.
0	*131216659.2* feet	1 circum.
1	*10934721.6* feet..............	1 hour.
2	*911226.8* feet..............	1 grad.
3	*75935.56* feet............	1 minute.
4	*6327.96* feet............	1 mile.
5	*527.33* feet............	1 cable.
6	*43.944* feet...........	1 chain.
7	*3.772* feet...........	1 metre.
The required unit of length	*43.944* inches........	1 metre.

The length of the circumference of the earth, divided by the seventh power of *12*, gives a length of *43.944* inches, which is assumed as a unit for all measurements of length, and which we will call a **metre.**

Twelve duodenal metres is a length of *43.944* feet, which is a convenient measure in the field or in surveys, and which we will call a **chain.**

Twelve duodenal chains is a length of *527.33* feet, which we will call one **cable.**

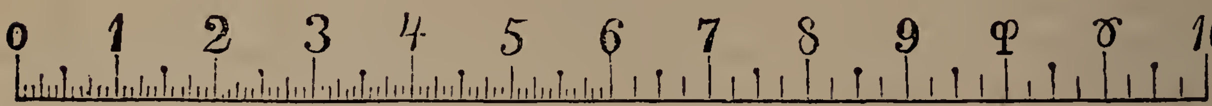
Twelve duodenal cables is a length of *6327.96* feet, which we will call one **mile.** The duodenal mile will be about *300* feet longer than our present knot or sea-mile.

$$\left.\begin{array}{ll}\text{Twelve duodenal miles} & =1\ \textbf{minute},\\ \text{Twelve duodenal minutes} & =1\ \textbf{grad},\\ \text{Twelve duodenal grads} & =1\ \textbf{hour},\\ \text{Twelve duodenal hours} & =1\ \textbf{circum},\end{array}\right\}\ \text{on the earth's great circle.}$$

The duodenal metre to be divided into twelve equal parts of *3.772* inches each, and called **metons.** The meton into twelve equal parts of *0.31433* of an inch each, called **mesans.** The mesan into twelve equal parts of *0.0262* of an inch each, called **metos.**

Fig. 235 shows the full size of a meton with its divisions.

Fig. 235.



The first 6 **mesans** are divided into **metos**, and the last into quarters of **mesans.** The ordinary shop-metre need not be divided finer than into quarters of **mesans,** for in so small divisions the **metos** can easily be approximated.

The **metons** and **mesans** would be the most convenient for expressing short measures in the mechanic arts.

Fig. 236.

Fig. 240.

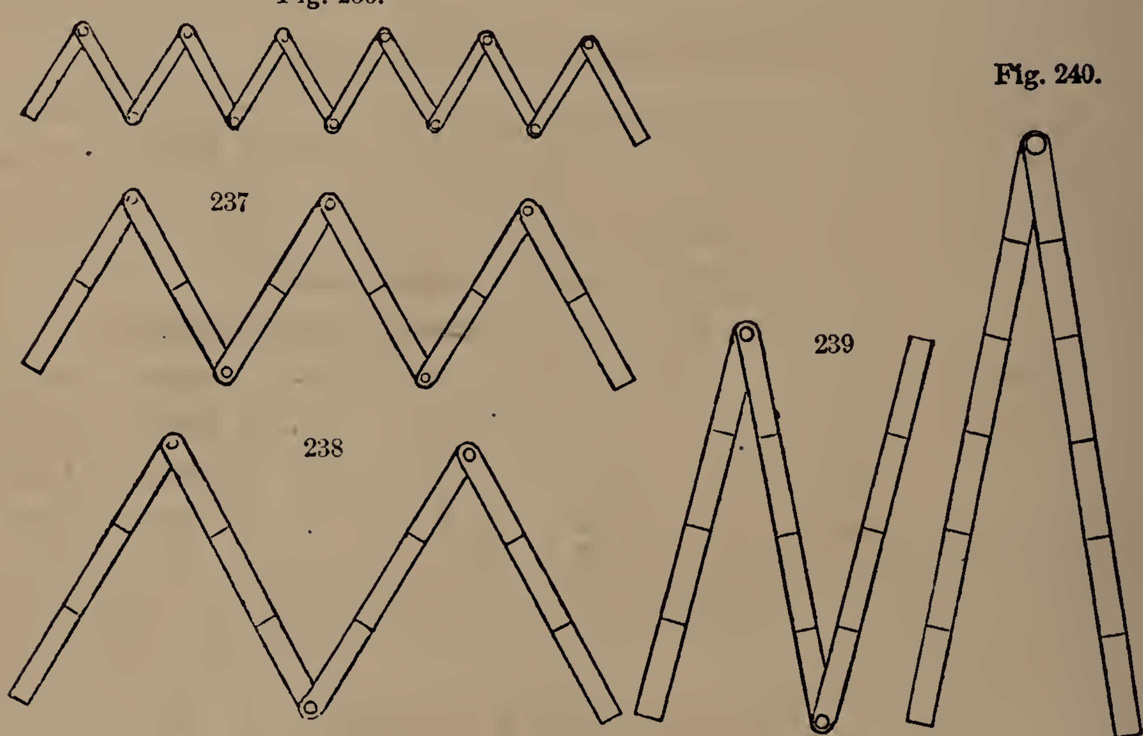


Fig. 236 represents a twelve-folded duodenal metre with lap-joints, like the ten-folded French metre; each part is one meton of *3.772* inches.

Fig. 237 represents a six-folded duodenal metre with lap-joints, of *7.544* inches in each. This form could be made with regular hinges like the English rule.

Fig. 238 represents a four-folded duodenal metre, with 3 metons in each part of *11.316* inches. This would be the most convenient form for the shop when folded with regular hinges like the English four-folded rule

Fig. 239 represents a three-folded metre, with four metons in each part of *15.088* inches.

Fig. 240 represents a two-folded metre, with six metons in each part of about *22* inches.

We see here that the duodenal metre can be folded into five different forms, with even measures in each part.

The longest unit of measure is the circumference of the earth, which ought to be termed a **circum.** The circum should be used in expressing astronomical distances.

The duodenal grad is 100 duodenal miles, or 0.01 of the earth's great circle, which would be a proper measure for expressing long distances on the earth's surface; and which would convey a correct idea of the real magnitude of such distances compared with the great circle.

The mile would be the common road measure and for traveling distances on land and sea.

Duodenal Measures of Length.

Circum.	Grad.	Mile.	Cable.	Chain.	Metre.	Meton.	Mesan.	Metos.
1	100	10000	100000	1000000				
0.01	**1**	100	1000	10000	100000	1000000		
0.0001	0.01	**1**	10	1000	10000	100000	1000000	
	0.0001	0.1	**1**	10	1000	10000	100000	1000000
	0.000001	0.01	0.1	**1**	10	1000	10000	100000
		0.001	0.01	0.1	**1**	10	1000	10000
		0.0001	0.001	0.01	0.1	**1**	10	1000
		0.00001	0.0001	0.001	0.01	0.1	**1**	10
			0.00001	0.0001	0.001	0.01	0.1	**1**

Division of the Circle.

The circle to be divided into 100 equal parts (144 decimal).

Duodenal System.		*Old System.*
One circle	= 100 grads.	*360* degrees.
One grad	= 100 lents.	*2* degrees *30* minutes.
One lent	= 100 ponts.	*1* minute *2.5* seconds.
One pont	=	*0.43418* of a second.
One quadrant	= 30 grads.	*90* degrees.

One duodenal mile on the earth's surface corresponds with an angle of one lent.

One duodenal chain on the earth's surface corresponds with an angle of one pont.

The latitude and longitude to be divided as the circle.

The angular measures correspond with the linear measures on the earth's surface. The terms minute and second are omitted in the division of the circle, so as not to confound angles with time.

The circle can thus be divided into *2*, *3*, *4*, *6*, *8*, *9*, *12* or *16* parts, without leaving fractions of a degree or grad.

The quadrant of the circle, containing 30 grads (*36*), can be divided into *2*, *3*, *4*, *6*, *9* or *12* parts without leaving fractions of a grad. These advantages with the duodenal division of the circle are of great importance in geometry, geography, trigonometry, astronomy and in navigation.

Either of the divisions corresponds with an even linear measure on the earth's surface.

Duodenal Division of Time.

The division of time should conform to that of the circle.

The time from noon to noon, including one night and day, to be divided into twelve equal parts, called hours.

	Duodenal System.	*Old System.*
1.	One day = 10 hours.	*24* hours.
	One hour = 10 grads.	*2* hours.
	One grad = 10 minutes.	*10* minutes.
	One minute = 10 lents.	*0.83333* of a minute.
	One lent = 10 seconds.	*4.1666* seconds.
	One second = 10 ponts.	*0.3472* of a second.
2.	One day = 10 hours.	
	One hour = 100 minutes.	
	One minute = 100 seconds.	
3.	One day = 100 grads.	
	One grad = 100 lents.	
	One lent = 100 ponts.	

Either of these three divisions can be used in practice. The first division includes the second and third.

If the duodenal division of time was introduced all over the world, some nations would probably use the second expression, and others the third, but the third division is the best, because the hands on the watch would show the number of grads.

In the notation of time, say 3 hours and 46 minutes, will appear 3.46 hours, or 34.6 grads, or 346 minutes.

5 hours, 36 minutes and 15 seconds will appear 5.36.15 hours, or 53.61.5 grads.

The conversion of angle into time, or time into angle, is only to move the point one place.

There is no necessity of *A. M.* and *P. M.* in the duodenal time.

Astronomers would surely use the third expression of time, which corresponds with the divisions of the circle.

Duodenal Clock-dial.

Fig. 241 represents a duodenal clock-dial.

The hour-hand makes one turn in one night and day.

The minute-hand goes round once per hour, and the second-hand once per minute.

Fig. 241.

The hour-hand will point to 10 at noon, to 3 at *6* o'clock in the evening, to 6 at midnight, and to 9 at *6* o'clock in the morning.

The length of the pendulum vibrating duodenal seconds will be

$$l = 39.1 \times 0.3472^2 = 4.711 \text{ inches, or}$$
$$= 1.3 \text{ metons.}$$

The duodenal metre will vibrate

$$n = \frac{6.254 \times 60}{\sqrt{43.944}} = 56.6 \text{ times per old minute.}$$
$$= 41.55 \text{ times per duodenal minute.}$$

Duodenal Year.

The year is already divided into twelve months, but the division is unnecessarily irregular.

No.	Days.	Months.	Days.	Old.
1	26	January,	*30*	*31*
2	26 †	February,	*30**	*28**
3	26	March,	*30*	*31*
4	27	April,	*31*	*30*
5	26	May,	*30*	*31*
6	27	June,	*31*	*30*
7	27	July,	*31*	*31*
8	26	August,	*30*	*31*
9	27	September,	*31*	*30*
♈	26	October,	*30*	*31*
♉	27	November,	*31*	*30*
10	26	December,	*30*	*31*
	265	Year.	*365*	*365*

The days in the year ought to be divided so as to make the months of nearly equal lengths.

The two months following one another—namely, December and January—have both *31* days, and then comes February with only *28* days.

There is no good reason why the months should not be divided so as to have *30* days in seven months and 31 days in five months of the year, as shown by the accompanying table.

Different calendars are also used in different parts of the world, which ought to be only one common calendar.

* In leap years February should have *31* days, or † *27* duodenal.

Duodenal Compass.

The compass to be divided into grads like the circle, but numbered from North and South toward East and West, making 30 grads in each quadrant. Fig. 242 represents a duodenal compass.

The hours 1 and 2, corresponding each with 10 grads, are marked on the dial in each quadrant.

The nomenclature will be nearly the same as for the old compass, only the expression of fractional points would be changed to grads; for example, **South South-East, one-half South,** would be called simply **South ott East.**

Our present compass is divided into *32* points, and each point into four quarters, making *32* divisions in each quadrant, which shows the natural tendency toward binary divisions; but it is accompanied with a clumsy nomenclature. A course of $3\frac{1}{4}$ points from North toward East is termed **North-East by North, one-quarter East.** The duodenal expression would be simply **North an tre Est,** meaning one hour and three grads from North toward East, without expression of fractions; and the course is given with greater precision than by the present nomenclature.

Fig. 242.

Duodenal Measurement of Surface.

Small surfaces can be expressed in square metres, square metons or square mesans.

Duodenal System.		*Old System.*
One square chain	= 1 lot.	
10 chains square	= 1 acre.	
One square cable	= 1 acre.	*6.3925* acres.
One acre	= 100 lots.	*278075* square feet.
One lot	= 100 square metres.	*1931.1* square feet.
One square mile	= 100 acres.	*920.52* acres.

One square grad = 10,000 square miles.
One square grad = 1,000,000 acres.

Duodenal Measure of Capacity.

The cubic metre to be the unit for capacity.

Duodenal System.		*Old System.*
One cubic metre	= 1 tun.	*49.113* cubic feet.
One tun	= 10 barrels.	*49.113* cubic feet.
One barrel	= 10 pecks.	*4.0927* cubic feet.
One peck	= 10 gallons.	*643.92* cubic inches.
One gallon	= 10 glasses.	*53.66* cubic inches.
One glass	= 10 spoons.	*4.47* cubic inches.

The duodenal gallon is one cubic meton, or about one quart. An ordinary quart bottle would contain one duodenal gallon.

Dry and wet measures of capacity should be measured by the same units. A cord of wood 10 cubic metres.

The volume of solids should be measured by the cube of the linear units.

Duodenal Division of Money.

The unit of money ought to be the value of one duodenal dram of fine gold, which is about one dollar.

Duodenal System.		*American Money.*
One dollar	= 10 shillings.	*1* dollar.
One shilling	= 10 cents.	*8.3333* cents.
One cent	=	*0.7* of a cent.

The American dollar is divided into ten dimes, but that expression is rarely used in the market. The same is the case with the French franc and dixiéme. The reason of that is that the decimal base does not admit of binary divisions. In a duodenal system the name of a twelfth part of a dollar would be used.

Dolls. Cts.	*Dolls. Cts.*	*Dolls. Cts.*
$\frac{1}{2}$ = 60	$\frac{7}{8}$ = Ҁ6	$\frac{3}{14}$ = 23
$\frac{1}{4}$ = 30	$\frac{1}{3}$ = 40	$\frac{7}{14}$ = 53
$\frac{3}{4}$ = 90	$\frac{2}{3}$ = 80	$\frac{Ծ}{14}$ = 83
$\frac{1}{8}$ = 16	$\frac{1}{6}$ = 20	$\frac{1}{20}$ = 6
$\frac{3}{8}$ = 46	$\frac{5}{6}$ = Ҁ0	$\frac{7}{20}$ = 36
$\frac{5}{8}$ = 76	$\frac{1}{14}$ = 9	$\frac{Ծ}{20}$ = 56

The 14ths in the duodenal system are the same as *16*ths in decimals.

The 20ths duodenal are 24ths decimal.

The duodenal system admits of binary division of the dollar as far as required in commerce and in the market.

Duodenal Measure of Weight.

The weight of one cubic metre of distilled water is assumed to be the unit of weight, and called one *ton.*

The duodenal ton will weigh about *3063.8* pounds, or *1.368* old tons.

Duodenal System.	*Old System Avoirdupois.*
One ton = 10 pud.	*3063.8* pounds avoirdupois.
One pud = 10 vegts.	*255.3166* " "
One vegt = 10 ponds.	*21.276* " "
One pond = 10 ounces.	*1.773* " "
One ounce = 10 drachms.	*2.3640* ounces "
One drachm = 10 scruples.	*0.1969* " "
One scruple = 10 grains.	*0.0164* " "
One grain =	*0.598* grains Troy.

Ton.	Pud.	Vegt.	Pond.	Ounce.	Dram.	Scruple.
1	10	100	1,000	10,000	100,000	1,000,000
0.1	1	10	100	1,000	10,000	100,000
0.01	0.1	1	10	100	1,000	10,000
0.001	0.01	0.1	1	10	100	1,000
0.0001	0.001	0.01	0.1	1	10	100
0.00001	0.0001	0.001	0.01	0.1	1	10
0.0000001	0.00001	0.0001	0.001	0.01	0.1	1

Units of Force.

Force can be measured by either one of the units of weight.

The pond would be the most convenient unit in estimating power and work in machinery.

Unit of Velocity.

Metons per second would be the most appropriate expression of velocity in machinery.

A velocity of metons per second is the same as miles per hour.

Unit of Time.

The second is the best unit of time to be used in the operation of machinery and falling bodies.

Unit of Power.

A force of one pond moving with a velocity of one meton per second to be one unit of power, and called **Effect.**

A power of one pond moving with a velocity of one meton per second would be = *1.605* foot-pounds per old second. This will make 30 duodenal effects per man-power, and 300 effects per horse-power.

Unit of Space.

The unit of linear space in the operation of machinery should be the meton or metre.

Unit of Work.

The work of lifting one ton through a height of one metre is a proper unit for estimating heavy work; it is equal to *11375* foot-pounds. This unit should be termed metreton and be used in the estimate of work of heavy ordnance.

The work which a laborer can accomplish per day would be about 100 metretons, which unit ought to be called a **Workmanday.**

The unit of work corresponding to velocity and effects should be one pond lifted one meton, which is *0.5567* of a foot-pound.

Unit of Mass.

The duodenal unit of mass would be the amount of matter in one cubic meton of distilled water, to be called one **Matt,** which is *53.668* cubic inches of water.

Unit of Gravity.

The velocity which a falling body would attain at the end of the first duodenal second is $g =$ 2.Ծ33 metres per second, which would be the acceleratrix of gravity.

Unit of Temperature.

The thermometer scale should be divided into 100 duodenal parts (*144*) between the freezing and boiling points of distilled water at the level of the sea in latitude 16 grads (45°).

One duodenal grad = *1.25*° Fahrenheit scale.

One duodenal grad = *0.69*° Centigrade.

Unit of Heat.

The heat required to raise the temperature of one pond of distilled water from ♈° to ♉° to be one unit of heat, which answers to *1713* foot-pounds of work.

Each kind of measure has different grades of units varying with the duodenal base, and any one of the units divided by 2, 3, 4 or 6 gives aliquot numbers in the quotient, which property renders the duodenal system very easy and clear to the mind for mental calculations and estimations of quantities.

In the establishment of a duodenal system of arithmetic and metrology it would perhaps be best to introduce the metrology first, and work it with decimal arithmetics until fairly established, after which the duodenal arithmetic would become more easy to learn and to apply.

The transition would not last long, for when one becomes imbued with the advantages and simplicity of the duodenal principles he would not bother his brain any more with the unnatural decimal base, but encourage others to take up the new system.

INDEX OF ILLUSTRATIONS.

The number at each illustration in the index refers to the page where the same illustration appears in the text.